PIER Energy-Related Environmental Research
Environmental Impacts of Energy Generation, Distribution and Use

The Use of a Cloud Physics Aircraft for the Mapping of Pollution Aerosols Detrimental to Winter Orographic Precipitation over the California Sierra Nevada

Contract #: 500-99-013, WA 90
Contractor: Woodley Weather Consultants
Contract Amount: $252,955
Contractor Project Manager: Dr. William L. Woodley
Commission Project Manager: Guido Franco
Commission Contract Manager: Gary Klein

The Issue

More than 15% of the electricity produced in California comes from hydropower[1]—an emissions-free, renewable energy source that relies on a dependable supply of water that can be dedicated to electricity generation. In California, a majority of this supply comes from precipitation in the Sierra Nevada mountains and from the snowpack that melts throughout the spring and summer.

However, researchers have documented an approximately 15%–20% reduction in precipitation in high elevations downwind of urban areas in California. New scientific evidence suggests that small aerosols (also known as cloud condensation nuclei, or CCN) from pollution tend to decrease precipitation. It is believed that the air pollution suppresses precipitation by reducing the ability of cloud droplets to form into raindrops, and by preventing the formation of ice particles and cold precipitation processes in clouds.

A likely explanation is that aerosols from air pollution serve as small CCN that form large concentrations of small cloud droplets, which take longer to gather together and rain than large droplets. Traditionally, when air is forced over mountains, the droplets in the air tend to precipitate and fall—a process known as "orographic precipitation." However, when the drops are small, they take longer to form ice crystals and fall as snow, so in California some of the precipitation occurs not as snow on the windward slopes of the Sierra Nevada (which would produce snowpack), but farther to the east of the Sierra crest (where they fall as snow or melt and

[1] California Energy Commission. California Gross System Power for 2004 in Gigawatt-Hours (GWh). www.energy.ca.gov/electricity/gross_system_power.html.

fall as rain). This effect reduces the amount of Sierra snowpack available to melt throughout the spring and summer to provide water for hydropower.

Project Description

PIER-funded research with Woodley Weather Consultants has estimated under what conditions the detrimental effect of aerosols is most pronounced, with the researchers basing their analysis on satellite data, which are used to infer the size of the droplets in clouds.

The contractor is now further documenting the effect of aerosols on precipitation patterns in the Sierra Nevada by using a research aircraft to collect and measure particulate matter aloft, CCN), and droplet size. The data will be used to validate the satellite measurements, increasing its credibility. The project is called The Suppression of Precipitation Experiment, or SUPRECIP.

The data collection effort involves north-to-south flight transects during storm events—progressively moving farther inland from the California coast to the Sierra, over the Sierra, and to the eastern Sierra to measure the CCN aerosols below the bases of the clouds and the in-cloud liquid water. The measured cloud properties will be compared with the satellite-based inferences of cloud properties.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Provide reliable electricity.** Hydropower production requires a dependable supply of water. This results of this project's research will help confirm the effect of California's small particle pollution on the precipitation that supplies that water for the state. This basic knowledge will help future research investigating methods to reduce this effect, as well as research focused on estimating state water supplies.

Final Report

PIER-EA staff intend to post the final report on the Energy Commission website by winter 2005 and will list the website link here.

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